

ABSORPTION MODEL OF AIR POLLUTERS AT INDUSTRIAL STACK USING COCONUT SHELL

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ABSTRACT

In minimizing emitted air pollutants, it is necessary to modify it by creating a pollutant absorber. Modifications are made in this research is by using coconut shell charcoal mounted on the end of industrial stack. The coconut shell used in absorbing air pollutants, before leaving the stack, while to keep the charcoal from burning, a condensation system is performed. The results showed that the concentration of SO₂ and dust contaminants decreased by 34% and 42%, respectively. The decrease in pollutant concentrations indicates that coconut shell charcoal used as a pollutant absorbent tool emitted from the industry. Among the two types of pollutants tested, it appears that coconut shell is more effective to absorb pollutants of dust. Therefore, other modifications are needed, so that the coconut shell can optimally absorb all types of air pollutants.

KEYWORDS: Minimization of Pollutants, Stack Modification, Coconut Shell Charcoal, Air Pollutants & Industry

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INTRODUCTION

Industrial development in Indonesia continues to increase every year, the Ministry of Industries, states that the non-oil and gas processing industry sectors were increased by 5.04% (Soerjono, 2015). The development of the industry spread throughout Indonesia with various capacities and fuel usage. The difference in capacity has the implications for pollutant concentration, while the fuel difference has the implications for the emitted pollutants (Pope, et al., 2010). The amount of emitted pollutant concentration was due to fuel's capacity and also depends on the atmospheric stability, while the spacing distance depends on the height of the stack used.

In minimizing emitted air pollutants, modifications are made by creating a pollutant absorber. Research related to the absorption of pollutants, including: Gas treating with chemical solvents (Astarita, Savage, & Bisio, 1983), Pollutant detection by absorption using mie scattering and topographic targets as retro reflectors (Byer & Garbuny, 1973), Effects on air pollutant removal by plant absorption and adsorption (Fuji, Cha, Kagi, Miyamura, & Kim, 2004), Environmental Samples Analysis by atomic absorption spectrometry and inductively coupled plasma-optical emission spectroscopy (Popescu, et al., 2009), and Light absorption by pollution, dust, and biomass burning aerosols: a global model study and evaluation with AERONET measurements (Chin, et al., 2009). Much of the research focused on reaction research, absorption rate, and CO₂ absorption efficiency system performed using absorber columns. At present, the modification of stacks to reduce emitted emissions is still limited to industries that use coal fuel. Stack modification done by installing Electricity Catalytic Oxidation (ECO) SO₂ and electrical

coagulation. Both modifications, each of which has a disadvantage, ECO-SO₂ is limited to the use of coal fuel, whereas electric coagulation devices require a voltage between 20,000-75,000 volts.

Studies of absorbent pollutants to minimize air pollutants emitted are continuously done, including by using coconut shell. Coconut fiber material serves as a filtering to minimize particulate PM_{2.5} emitted from motorcycle (Wahyuningrum, Wardoyo, & Darmawan, 2018). In an another study, coconut shell used as an activated coconut has potential as an absorbent of CO, NO and NO_x emissions emitted from motor vehicles (Verlina, Wahab & Maming, 2018), and coconut shell charcoal can be used as emission filter on motorcycle exhaust (Mahendra, Qomaruddin, & Mulyahati, 2017). Currently, research on the use of activated carbon from coconuts, both shell and coconut husk is limited to the use of small and unused fuel capacity for industry. Referring to the research, conducted research on the use of coconut shell charcoal mounted on the industrial stack. The study conducted with the aim to minimize air pollutants emitted from the industry. Coconut shell charcoal assumed to absorb air pollutants before leaving the stack, while to keep the charcoal from burning done by condensation system.

THE APPLICATION OF AIR POLLUTERS

The Application of Air Polishing with Coconut Shells

The study of the absorption of air pollutants in industrial stacks as an effort to minimize the concentration of pollutants emitted has been widely done, either through experiments or simulations. Kusminingrum (2014) made a study on the effectiveness of air pollution reduction by vertical garden method. Vertical garden method can expand the field of plant contact with air to improve the effectiveness in reducing the air pollution. In addition, Syakur, Warsito & Nurlailati (2009) use an electric voltage to reduce dust pollutants with a metal strip filter arranged in parallel. The disadvantage of the use of such metal plate filters is the need for regular cleansing of the plates at a maximum of 54 hours so that the precipitating device remains effective. Another drawback is the need for a voltage of 4,560.2 volts to precipitate dust. Furthermore, Gianto, Sarwoko & Kurniawan (2015) made the design and implementation of high-voltage electrostatic dust setters. Based on the studies it is known that electrostatic can precipitate dust, but the effectiveness of the tool reduced if too much dust is deposited, and it takes a voltage of 4,020 volts. Another way to minimize pollutant emissions by designing absorbent tools in the stack, such as by using an absorbent filter derived from coconut shell charcoal. Meanwhile, Ansyori (2011) conducted a study on the control of mercury emissions in the industrial stacks on the use of coal as fuel. The study conducted at (PLTU) Power Generation Business Unit PT Indonesia Power Suralaya. The results of the study found that the lowest mercury emissions from stacks in coal combustion occurred in bituminous and sub bituminous coal with fabric filters, as well as lignite coal with ESP and Wet Scubber. Furthermore, Ruhiat, Wibowo & Oktarisa, (2015) made a simulation of air pollutants minimization of pollutant absorber with condensation system. Simulation results show that the emission of sulphur dioxide (SO₂) contaminants decreased by 38%, Nitrogen oxide decreased by 37%, and dust decreased by 64%. Referring to the previous research, a model of minimizing emissions with coconut shell as a pollutant absorber made.

The model of air pollutant absorption with coconut shell is shown in the Figure 1 below. The absorption process of air pollutants emitted as follows:

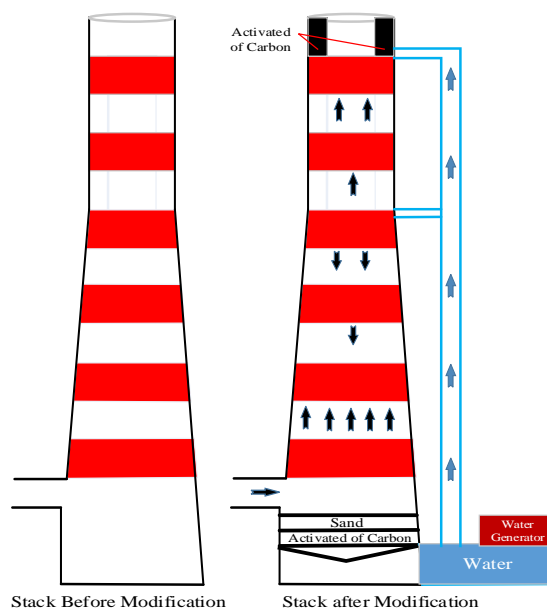


Figure 1: Stack Modification

- Coconut shell charcoal is installed at the end of the stack, which serves to absorb air pollutants before leaving the stack.
- To keep the coconut shell from burning, condensation is done by draining the water on the pipe.
- The condensation function on the coconut shell aims:
 - to keep the coconut tempurug not to burn
 - to absorbs air pollutants
 - to change the density of the air pollutant, so that the contaminant falls back to the bottom of the stack.
- To accommodate the type of pollutant yag fell to the bottom of the stack, installed tubes containing sand and activated carbon.
- The reservoir at the bottom of the funnel serves to collect the pollutant, then the pollutant is filtered by sand.
- The installation of coconut shell charcoal at the end of the stack, and the activated carbon and sand at the bottom of the stack is intended to allow the absorber to work optimally for a longer time.

Analysis on Emission and Distribution of Air Polluters from Industry

To test the absorption of air pollutants by coconut shells, an analysis of the distribution of air pollutants in the industrial areas is carried out. Simulation is done by using emission data from industry in Cilegon industrial area. To examine the reliability of pollutant absorbers from coconut shells, a simulation of industries with various fuels was conducted, so that the dominant picture of the percentage of pollutants absorbed by the coconut shell can be obtained. Another thing of this simulation is to obtain information on the function of coconut shell charcoal in absorbing various types of air pollutants emitted from various fuels used.

Pollutants emitted from industry depend on the type of fuel used. In general, air pollutants emitted from the industry consist of five groups, namely carbon monoxide (CO), nitrogen (NO_x), sulfur oxide (SO_x), hydrocarbons (HC), and particulate matter (PM) dust. The amount of pollutant concentration emitted, according to IPCC (2006) the amount of air pollutant concentration is directly proportional to the amount of emitted pollutant concentration. Pollutant emissions (Q) based on fuel consumption, are analyzed using the equation:

$$Emission = \sum a[Fuel \times FEa] \quad (1)$$

With the emission is *a* certain emission load of pollutants (kg), *Fuel a* is a fuel consumption of type *a* (ton hour), *FEa* is emission factor (kg/ton hour), and *a* is the type of fuel used. To apply equation (1) analysis of air pollutant emission in Cilegon industrial area is completed. The amount of emission of air pollutants emitted from industry is shown in the Table 1 below:

Table 1: Result of Air Pollutant Emission Analysis Emitted from Industry

No	Company		Type of Fuel	Amount of Fuel (10 ³ kg/h)	Pollutant			Efficiency			Emission		
					SO ₂ (%)	Carbon (%)	Dust %	SO ₂ (%)	Carbon (%)	Dust %	SO ₂ (gr/sec)	CO (gr/sec)	Dust (gr/sec)
1	PT	Krakatau Daya Listrik	Residue	80.00	0.08	8.30	0.02	0.00	0.00	0.00	33.33	259.26	4.44
2	PT	Chandra Asri	Diesel Fuel	1.00	0.05	0.00	0.00	0.00	0.00	0.00	0.25	3.24	0.00
			PFO	3.72	0.01	0.00	0.00	0.00	0.00	0.00	0.27	12.06	0.00
			MFO	3.76	0.01	8.60	0.01	0.00	0.00	0.00	0.21	12.19	0.10
3	PT	Cigading	Residue	80.00	0.05	8.50	0.02	0.03	0.03	0.00	22.22	259.26	4.44
4	PT	Indonesia Power											
		Unit 1 - 4	Coal	680.00	0.30	49.00	6.00	0.00	0.00	99.50	1,133.33	2,203.70	56.57
		Unit 5 - 7	Coal	765.00	0.30	49.00	6.00	0.00	0.00	99.50	1,275.00	2,479.17	63.75
5	PT	Krakatau Steel	HSD	170.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	553.19	0.00
			MFO	444.44	0.01	0.00	0.01	0.00	0.00	0.00	24.69	1,440.31	12.35

Based on the Table 1, it appears that the largest capacity in the region uses coal fuel. Comparison of the use of residue fuel with coal amounted to 0.105 while the ratio of pollutant emissions of SO₂, CO and dust are 0.026, 0.118, and 0.070 respectively. Then, the comparison of fuel and diesel fuel with coal is 0.001, whereas the ratio of CO₂, CO and dust pollutant emissions are 2×10^{-4} 0.001, and 0.000 respectively. Furthermore, the comparison of fuel usage of Pyrolysis Fuel Oil (PFO) with coal is 0.005, while the ratio of pollutant emissions of SO₂, CO and dust are 2×10^{-4} , 0.005, and 0.000, respectively. Comparison of the usage of Marine Fuel Oil (MFO) with coal between 0.105-0.583 while the ratio of pollutant emissions of SO₂, CO and dust between 0.017-0.19, 0.118, and 0.070 respectively. Meanwhile, the comparison of the usage of High Speed Diesel (HSD) fuel with coal amounted to be 0.223, while the ratio of pollutant emissions of SO₂, CO and dust were 0.000, 0.251, and 0.000 respectively. Thus, it appears that fuel use does not emit dust contaminants, and HSD fuel does not emit SO₂ and dust. Meanwhile, the residue fuel, MFO and coal emits SO₂, CO and dust pollutants, but the pollutant is emitted from coal fuel. The amount of pollutants emitted is assumed to spread beyond the industrial estate.

Air pollutants emitted from the industry depend on the fuel capacity, the larger the fuel capacity used, the greater the concentration of emitted pollutants. To analyze the concentration of emitted air pollutants, the following equation (Zanneti, 1990) is used:

$$C_{ij} = \frac{Q}{2\pi\sigma_y\sigma_z u} \exp\left[-\frac{1}{2}\left(\frac{y_r}{\sigma_y}\right)^2\right] \exp\left[-\frac{1}{2}\left(\frac{h_s + \Delta h - z_r}{\sigma_z}\right)^2\right] \quad (2)$$

where C_{ij} (gm^{-3}) is air pollutant concentration at a receptor, Q (gs^{-1}) is pollutant emission rate from a source facility, Δh (m) is emission plume rise, and h_s (m) is height of the source (stack height). The results of pollutant concentration analysis using equation (2) with an average wind speed of 2.45 m / s shown in Table 2 below:

Table 2: Air Pollutants Distribution Analysis Results From Industry

No	Company		Amount of Fuel (10^3 kg/h)	High of Stack (m)	The Concentration of Air Pollutant	
					SO ₂ ($\mu\text{g}/\text{m}^3$)	Dust ($\mu\text{g}/\text{m}^3$)
1	PT	Krakatau Daya Listrik	80.00	36	61.130-222.200	8.143-29.590
2	PT	Chandra Asri	1.00	41	0.103-0.579	0.004-0.021
			3.72			
			3.76			
3	PT	Cigading	80.00	60	11.990-49.520	2.396-9.894
4	PT	Indonesia Power				
		Unit 1 - 4	680.00	200	12.680-866.000	0.634-43.300
		Unit 5 - 7	765.00	275	1.070-592.400	0.060-33.320
5	PT	Krakatau Steel	170.00	30-80	9.163-53.380	4.583-27.180
			444.44			

Based on the Table 2, the highest concentration of SO₂ and dust contaminants from the industry using coal fuel, while lowest with MFO fuel. From the table it also appears that the ratio between the fuel capacity with the height of the stack between $(29-75) \times 10^{-3}$ while the emission concentration is between 0.004-1.698. The greater the ratio between the fuel capacity and the height of the stack, the greater the concentration of pollutants emitted, or vice versa. In other words, the greater the fuel capacity, the higher the stack is used, whereas in terms of emissions, the higher the stack is used, the smaller the concentration of the emitted contaminants.

Refers to Tables 1 and 2 primarily on the type of fuel, fuel capacity and the height of the stack used. At the same fuel use capacity, but the type of fuel is different, then the height of the stack is also different. However, the emission concentration emitted is related to the height of the stack used. The higher the stack used, the more distant the spread of air pollutants emitted (Ruhiat, 2009). However, not all industries use a high stack, so to minimize the concentration of pollutant dissemination is done by absorption.

The Effectiveness of the Absorber Coconut Shell Tools

In minimizing the spread of pollutants emitted, several industries have made efforts to modify the stack. In this study, modification of stack by using coconut shell as absorber, as shown in Figure 1. To test the reliability of coconut shell in absorbing air pollutant, simulation conducted. Analysis of air pollutant concentration emitted from industry, before and after installed pollutant absorber, used equation (Hirabayashi, Kroll & Nowak, 2012):

$$C_f = C_{ij} - C_{ad} \quad (3)$$

With C_f (gm^{-3}) concentrations of contaminated air pollutants to the environment, C_{ij} (gm^{-3}) concentrations emitted prior to the absorbent filter installed, and C_{ad} (gm^{-3}) concentrations of air pollutant emitted from the industrial

measurements after insertion filters installed. The simulation results using (3) shown in Table 3 below.

Table 3: Simulation Results Before and After the Installation of Coconut Shell

No	Company		Type of Fuel	The Concentration of Air Pollutant (ug/m ³)			
				Before Modification		After Modification	
				SO ₂	Dust	SO ₂	Dust
1	PT	Krakatau Daya Listrik	Residue	222.200	29.590	75.55	13.43
2	PT	Chandra Asri	Diesel Fuel	0.579	0.021	0.28	0.04
			PFO	0.237	0.012	0.09	0.02
			MFO	0.103	0.004	0.04	0.00
3	PT	Cigading (Pembangkit Listrik)	Residue	49.520	9.894	17.84	5.16
4	PT	Indonesia Power					
		Unit 1 - 4	Coal	866.000	43.300	295.44	19.19
		Unit 5 - 7	Coal	592.400	33.320	205.42	13.99
5	PT	Krakatau Steel	HSD	53.380	27.180	18.15	11.42
			MFO	9.163	4.593	3.16	1.93

Based on the Table 3, it appears that SO₂ concentrations before and after coconut shell installation averaged 34% while dust decreased by 41%. The largest percentage of absorption occurs in dust pollutants, therefore coconut shell charcoal potentially made as absorbent material of air pollutant emitted from the industry.

CONCLUSIONS

The characteristics and concentrations of pollutants depend on the type of production, production equipment, and fuel capacity used. If an industry uses coal fuel then the rest of its combustion is in the form of fly ash (fly ash) and ash below (bottom ash). In minimizing pollutants emitted from the industry, coconut shells can effectively absorb pollutants before leaving the stack. The absorption of pollutants by the coconut shell in the stack is able to minimize the concentration of pollutants emitted for pollutants SO₂ by 34% while for dust by 41%.

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